SMALL HYDRO GENERATION BUILDING BLOCK PROFILE

Prepared for:

Economic Development Branch
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BUILDING BLOCKS FOR ECONOMIC DEVELOPMENT & ANALYSIS

PREFACE

PURPOSE

Building Blocks have been conceived and developed by the Economic Development Branch of the Ministry of Sustainable Resource Management, under the guidance of Nancy South, Manager Economic Analysis, as an analytical tool that supports British Columbia coastal and land and resource use planning and decision-making and economic development initiatives. The Blocks contain concise business and sector information for a broad range of resource-based business types in BC. At this point, there are more than 30 Blocks either complete or in draft form. Several more Blocks have been identified as high priority by planning tables and other client groups. Additional Building Blocks will be developed over time, and some Blocks may be updated. For the most current Building Blocks, please see the Ministry of Sustainable Resource Management website, at: http://srmwww.gov.bc.ca/rmd/ecdev/

ACKNOWLEDGEMENTS

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BENEFITS

Building Blocks are expected to provide the following general benefits:

- Increase efficiency and more informed decision-making by providing readily accessible, credible information to planning and economic development processes;
- Improve the consistency of economic information across planning areas;
- Support economic analysis and decision-making that occurs outside formal coastal and land use planning processes; and
- Provide linkages between economic analysis and other social and environmental analytical tools (through identifying resource requirements to support economic activities and general compatibilities with other sectors and values).

LIMITATIONS

Every effort has been made to ensure that the information contained in Building Blocks is accurate and consistent. Approved, credible data sources are the foundation for Building Blocks. All Blocks were reviewed by sponsoring agencies and other experts. However, users are cautioned that information is used at their own risk, and that the authors and sponsors are not liable for any damages. Any conclusions or interpretations by the authors are not intended to represent government policy. Also, note that Building Blocks do not provide site specific information nor do they consider requirements for sustainability (social, community, environmental).

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RECOMMENDED REFERENCE/CITATION

BC Ministry of Sustainable Resource Management, 2003, Building Blocks for Economic Development and Analysis, *[Title of Sector]*. http://srmwww.gov.bc.ca/rmd/ecdev/

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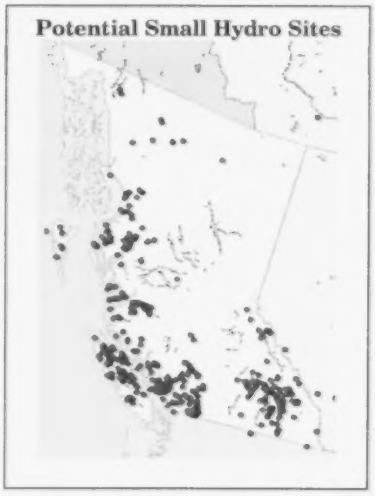
1.0 OVERVIEW

1.1 Description

- BC's steep terrain and abundant precipitation produce many opportunities for hydropower generation. Hydropower presently supplies approximately 90% of BC's electrical demand. BC is the second largest producer of hydropower in Canada.
- Existing hydropower in BC is mainly from large dams on the Columbia and Peace Rivers.
- While there are several potential large hydro sites in BC, these are unlikely to be developed due to their high impact on the surrounding environment; however, significant potential exists for development of small hydro sites, which have a much lower environmental impact.
- Although potentially economic sites exist throughout the province, the highest concentrations are located near main transmission lines in the Coast Mountains, Vancouver Island and on the west slope of the Rockies and Selkirks.
- This building block focuses on "run of the river" small hydro sites in the range of 0.5 to 50 MW that do not have any appreciable water storage.
- Small hydro sites with storage (either natural lakes or artificial) generally have somewhat improved economics, but are rare due to environmental and permitting issues.
- The majority of potential small hydro sites are below 20 MW due to geography. Sites over 50 MW are significantly more difficult to permit as they require a more rigorous environmental assessment.



1.2 Major Components

- Weir / Intake – The weir creates a pool deep enough for the intake to remain submerged at all times. The intake directs water from the normal stream course to the small hydro project and eliminates air and debris carryover.
- Water Conveying System – The water conveying system carries water from the intake to the turbine. Water conveying systems may be up to several kilometers long and are usually pipes (penstocks) made of wood, plastic or steel but can also be canals or tunnels or combinations thereof.
- Turbine Generator – The turbine converts the high-pressure water from the water conveying system into mechanical energy. The generator converts the mechanical energy from the turbine into electrical energy for sale. Often two or more turbines are installed to improve the efficiency at low season water flow rates. Two turbines can be arranged on a single shaft with a single generator to reduce costs.
- Powerhouse – The powerhouse is a small building that contains the turbine generator, controls, maintenance crane and other equipment.

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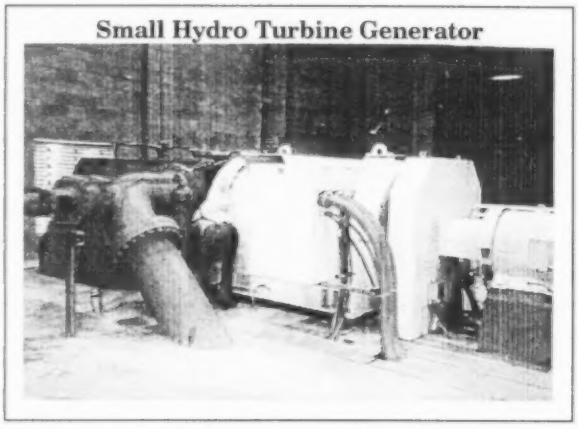
- Tailrace – The tailrace returns free flowing water from the discharge of the turbine to the stream and is usually an open channel.
- Substation – The substation contains a transformer to increase the generator voltage to transmission system voltage. Switchgear and controls protect the power plant and transmission system from negative interactions.

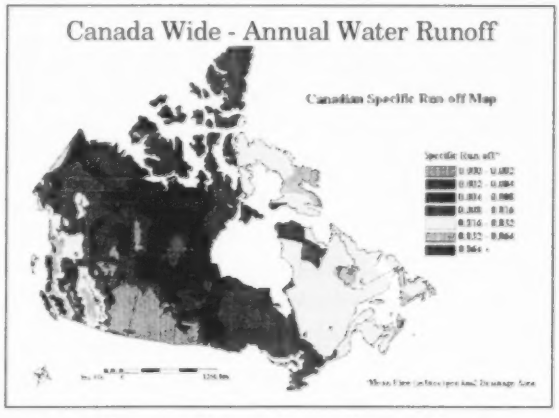
1.3 State of Technology


Small Hydro Turbine Generator

- The technology for economic small hydro development is mature with many proven designs operating in BC and around the world.
- Incremental advancements are constantly being made to improve the efficiency, and cost of small hydro projects.
- Turbine efficiencies in the range of 80% to 90% are common.
- Generator efficiencies in the range of 93% to 98% are common.
- Transformer efficiencies are approximately 99%.
- Parasitic losses due to auxiliary systems are typically 1 to 2%.
- Overall water to wire efficiencies are typically between 80% and 85%.

2.0 LAND RESOURCE

2.1 Geographic Factors



- The most attractive sites are steep sections of streams located close to a 69 kV or lower voltage transmission line, substation or a large electrical load.
- Power output is the product of the head, flow and efficiency. Low head sites require high water flows and large diameter water conveying systems and turbines, which add considerably to the capital cost. The higher the head of the site the lower a water flow is required to be economic.
- Typical head (elevation change) requirements are 30 m to 500 m depending on flow, although lower head systems can be economic at very high flows.
- Typical flow requirements are in the range of approximately 1 to 100 m^3/s depending on the available head.

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- Potential sites exist all throughout the Coastal Mountains; however, access to transmission lines limits the economic projects to Vancouver Island and the regions around Vancouver / Whistler / Kamloops / Hope and Prince Rupert / Kitimat.
- Due to the availability of transmission lines throughout the Kootenay region there are many potentially economic sites spread out over a large area.
- Locations with more uniform seasonal water flows have improved economics as the ratio of installed capital cost to average energy production is better. The capacity factor is used to describe this feature and is defined as the average energy production divided by the peak installed capacity. Capacity factors vary significantly from site to site, but for "run of the river" projects are most often in the range of 45 to 65%.
- Coastal projects generally have the lowest seasonal variation and highest capacity factors.
- Coastal projects also have the advantage of warmer winter temperatures which result in higher winter stream flows when power prices are typically highest.
- Inland projects generally have lower capacity factors due to dry summers and high winter snow packs. Low flows in inland regions are typically found in the winter months while the snow pack is accumulating.

2.2 Land Resource Requirements

- "Run of the river" small hydro projects require mainly linear corridors for transmission lines, water conveying systems and roads.
- Some land area is also required for the weir / intake and powerhouse / substation, which are typically on the order of 1 hectare each.
- Land requirements for projects with water storage are much greater as large areas are often flooded.

2.3 Environmental Impact

- Both large and small hydro projects are renewable, sustainable and do not contribute to global warming.
- "Run of the river" small hydro projects typically have minimal impact on the local environment and wildlife, as there is no change to the downstream water flow rate and no flooding required for storage.
- "Run of the river" small hydro projects do not effect the upstream or downstream flows, but do reduce stream flow between the intake and tailrace. Usually a minimum stream flow bypassing the small hydro project is required to protect fish habitat.
- Most economic small hydro sites are situated at sites that are typically too steep to naturally support salmon or other migratory fish species.
- There is sometimes significant public concern over aesthetic, health and environmental impacts of new transmission lines.
- Proper design of the powerhouse can reduce ambient noise created by the turbine generator and auxiliaries to acceptable levels.
- Natural and biodegradable lubricants can be used.
- In some cases penstocks can be installed underground in a trench to reduce environmental impact. The use of tunnels between the intake and powerhouse can

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further minimize environmental impact. Underground powerlines are too expensive to be economically feasible except for very short distances.

- Small hydro projects are often installed in areas that have been previously used for forestry purposes and often have little increased impact on the surrounding area.
- Non-integrated communities and work sites that are not connected to the BC Hydro transmission system often use diesel fired engines for power generation. Small hydro projects can replace part or all of the required diesel fired power generation and reduce air emissions such as CO_2 (a greenhouse gas), CO, NOx, and SOx.

2.4 Competing Uses

- Small hydro development may conflict with local tourism if the stream or surrounding area is popular with hikers and adventure kayakers. In some cases, development can be beneficial by providing new access to streams and areas that were previously inaccessible.

2.5 Social Impacts

- Due to the remoteness of most small hydro sites, social impacts are usually minimized.

3.0 INFRASTRUCTURE REQUIREMENTS

3.1 Transmission Service

- For sites to be economic they must be located in close proximity to a 69 kV or lower transmission line. Proximity to transmission lines above 69 kV is less advantageous as the additional substation costs are often prohibitive to development.
- The distance and terrain between the site and transmission system can have a significant effect on the total capital cost and economics of a given project.
- At today's power prices, a 10 to 20 MW project must typically be within 10 to 15 km of transmission service; however the better the site and power sales price, the greater the economic distance.
- The majority of new powerlines will be 25 kV; however, larger projects, or those greater than approximately 50 km from an interconnection, may be up to 69 kV or greater to reduce power losses.

3.2 Road / Town Access

- Road access and close proximity to a medium sized town (~50,000 or larger) is desirable it will reduce construction costs, but is not strictly required.
- Road access and close proximity to a small village is generally sufficient to minimize operating costs as long as it can provide accommodation for the full time operator(s).
- Sites with barge or air access only may still be developed economically depending on other factors such as proximity to transmission grid, size of resource, etc.

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3.3 Access to Labour

- Poor access to labour increases capital costs during construction, but is not strictly prohibitive as ongoing operating and maintenance labour requirements are low.

3.4 Communications

- Telephone communication is required for remote operation of the small hydro plant.

4.0 SALES MARKET

4.1 Products

- The product from small hydro projects is electrical power / energy.
- Power from small hydro projects often receives a premium due to the fact that it is considered a "green" form of energy for which some consumers are willing to pay more.
- Presently the market for greenhouse gas credits is not well developed; however these will likely grow in importance and value over time.

4.2 Sales Market

- The vast majority of projects will sell power to BC Hydro under long term contract.
- Some projects may sell directly to other provincial utilities, such as Aquila Networks Canada (formerly West Kootenay Power) and Powerex (a power marketing company wholly owned by BC Hydro).
- Direct sales to the U.S. and other provinces are possible; however to date, few developers have opted to transport power through BC Hydro's transmission system under the present wheeling system and rate structure.
- Direct sales to individual consumers for self-consumption are also possible, but unlikely as BC Hydro offers a higher price for the power than large consumers presently pay. Sales to BC Hydro also offer greater long-term security. Note, however, that the BC Energy Plan contains policy actions (14 and 21) which may encourage large customers to acquire some of their power needs from the private sector.
- Direct sales to remote work sites or communities are possible where customers are not connected to the transmission system. Power for these sites is usually generated with diesel engines and is significantly more expensive than the typical power prices in BC.
- Some future revenue may be realized through sales of greenhouse gas credits; however, BC Hydro presently claims these credits when purchasing power from small hydro projects.

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5.0 LABOUR MARKET

5.1 Employment Generated

- Approximately 10 to 20 person years of employment are generated in the permitting and project development phase of each project. This work would typically performed by highly skilled professionals employed in BC such as business people, engineers, lawyers, environment consultants, etc.
- Approximately 10 to 20 person years of design and engineering work is created per project. This work would be performed by BC companies employing professional engineers and trained draftsmen.
- Approximately 30 to 80 person years of employment are created during construction of these projects (1 to 2 years). The majority of this work is performed by local civil / structural, mechanical and electrical contractors employing skilled trades people.
- Most of the major equipment is presently supplied from out of province. One supplier of equipment below approximately 10 MW is located in BC and others may eventually relocate here if a large enough market develops.
- Projects typically require one or two full time operators with strong technical and mechanical skills.
- Skilled maintenance technicians are required for annual turbine generator maintenance work. These workers will travel from major centers to the site.
- Seasonal site work is required by local contractors for silt / debris removal and maintenance of structures.

5.2 Seasonality / Work Intensity

- The work is seasonal only to the extent that some construction elements must be carried out during "windows" designated by fisheries agencies.
- Much of the employment opportunities are focussed around the development and construction of new projects.
- Ongoing labour requirements are typically limited to one or two fulltime operators.

5.3 Wage Rates

- Average wage rates are high as most work involves highly skilled labour such as engineering and industrial construction work.

5.4 Associated Companies

- BC Hydro
- Consulting Engineers
- Construction Contractors
- Equipment Suppliers

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6.0 REGULATORY REGIME

6.1 Permitting and Approvals

- Numerous permits and approvals must be received before a project can be initiated. This is a time consuming and costly exercise for all developers. The main approvals which must be received are from the following government agencies:
  - Land, Water and Air BC
  - Department of Fisheries and Oceans
  - Canadian Environmental Protection Agency
  - *Navigable Waters Protection Act* (DFO / Coast Guard)
- BC and Federal environmental assessments must be undertaken for all projects.
- Currently, projects above 50 MW must go through the process administered by the Environment Assessment Office.
- Native bands, local governments and other stake holders must be consulted.
- Water rights must be negotiated with the BC government.
- Right of ways must be secured for new roads and powerlines.
- There are presently no standards for permitting and licensing. This increases development costs and delays many projects.
- Typically a power purchase agreement must be arranged with BC Hydro. This can require one to two years.
- Note that in addition to the main approvals listed above, small hydro projects must be constructed and operated in accordance with numerous federal and provincial acts and regulations such as (from Ref 17):
  - *Fisheries Act* (Canada)
  - *Canadian Environmental Protection Act* (Canada)
  - *BC Fish Protection Act*
  - *BC Fisheries Act*
  - *BC Land Act*
  - *BC Wildlife Act*
  - *BC Environmental Management Act*
  - *BC Waste Management Act*
  - *Transportation of Dangerous Goods Act* (BC)
  - *BC Heritage Act*
  - *BC Soil Conservation Act*
  - *BC Forest Act*
  - *BC Water Act*
  - Forest Fire Prevention Regulations
  - Special Waste Regulations
  - Guidelines for the Use of Explosives in Canadian Fisheries Waters
  - Land Development Guidelines for the Protection of Aquatic Habitat
  - *Navigable Waters Protection Act* (DFO / Coast Guard)
  - Environmental Objectives and Procedures for Water Crossings
  - Water Quality Criteria Approved and Working Criteria for Water Quality
  - Archaeological Impact Assessment Guidelines

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7.0 DEVELOPMENT FACTORS

7.1 Government Influenced

- BC Hydro is presently the main purchaser of power from small hydro projects and has created a regular call for tender process for the purchase of this power. The timing of these calls for power are often ill-suited to many projects, which can cause significant delays as projects wait for up to a year for the next call to be issued. The process itself then requires over one year to complete. Until the power purchase agreement is signed, little development work can take place, thus projects are often delayed by between one and two years.
- BC Hydro presently offers higher prices for power on Vancouver Island and in the lower mainland based on the relative value to BC Hydro considering related transmission costs. This encourages development of small hydropower in those regions.
- Transmission line and road development can improve the economics of sites that are presently too remote.
- Often several small hydro sites are clustered in a remote region where none of the individual sites can support the cost of a new powerline. A large developer, or BC Hydro, may be able to share the cost of the powerline between several small hydro sites, but would need assurance that permitting and licensing for all sites would be granted.
- The amount of in-stream flow (between the intake and the powerhouse) which must be reserved to maintain fish habitat has a very significant effect on project economics. Present requirements may be 10 to 20% of the mean annual flow, which is often many times higher than the natural minimum flow.

8.0 Non-Governmental

- Interest rates are one of the most important factors as debt servicing is by far the largest operating expense for small hydro projects. Interest rates are influenced by the Bank of Canada's prime rate, however the prime rate is generally adjusted according to factors outside the federal government's immediate control.
- If a freemarket for power was established in BC, market electricity pricing and stability would effect development of small hydro projects.
- Exchange rates have a significant effect on the capital cost of a project as much of the major equipment is purchased from outside Canada such as the U.S. and Europe.
- Construction labour rates can have a significant effect on the capital cost of a project.
- Variations in the price of natural gas effect BC Hydro's marginal cost for power. Long term changes in natural gas prices will effect their offering price for new power generation.
- Variations in diesel fuel prices are often short in duration compared to the life cycle of small hydro projects; however, long term changes in diesel fuel prices may have an effect on the development of small hydro sites supplying power to non-integrated communities or work sites.
- The development of new non-integrated work sites may increase opportunities for small hydro projects; however, these must be long term stable businesses to support small hydro projects.

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9.0 INVESTMENT AND ECONOMICS

9.1 Development Costs

- Stream flow monitoring of at least 1 to 3 years is required to quantify the energy resource and determine the project economics.
- Preliminary Studies to determine optimal project site, size, etc. typically cost $100,000 to $500,000 depending on the size, complexity and number of sites being evaluated.
- Permitting and licensing costs are the most significant development expense and often represent 5 to 10% of the total capital cost.
- Development costs are mostly independent of the project size, increasing the relative cost of smaller projects.

9.2 Project Capital Costs

- Small hydro projects are very capital intensive. Most of the cost of power from small hydro projects is in debt repayment and interest.
- The cost of permitting and licensing in BC is presently on the order of 5 to 10% of the total capital cost.
- The turbine generator and controls, water conveying system and electrical interconnections are the most significant cost items.
  - The cost of the turbine generator and controls varies depending on the type flow and head, but is typically in the range of $300/kW to $600/kW.
  - Water conveying systems can vary greatly in cost depending on the type, flow, terrain and length.
  - Typical costs for transmission lines are often approximately $70,000 per km, but can vary significantly depending on terrain and access.
  - Presently BC Hydro requires developers to pay for modifications and protection associated with the interconnection to the transmission system. This cost can vary greatly from site to site and is unknown until determined by BC Hydro.
  - Other significant direct costs include the weir, intake, tailrace, powerhouse, substation, site work, and road access.
  - The cost of engineering is very site specific and depends upon the size and complexity of each project.
  - Interest accrued on the debt during the construction period is typically between 6% and 10% of the total capital cost.
  - A contingency of 10 to 20% is usually included in the construction cost estimate.
  - Development costs include: initial studies, project management, general / administration, etc.
- At present power prices in BC ($0.05 to $0.06/kWh), small hydro projects generally need capital costs less than approximately $2,000/kW to be economic. Higher specific capital costs will require higher power sales prices to be economic.

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Example Project Capital Costs

All Costs in Millions of Dollars

Cost Item	Approximate Range	4.5 MW Project	6.0 MW Project	8.0 MW Project	27.0 MW Project
Head	30 - 500 m	510 m	30 m	460 m	45 m
Design Flow	1 - 100 m3/s	1.1 m3/s	26.5 m3/s	2.1 m3/s	75.0 m3/s
	% of Total				
Weir / Intake(s)	2 - 5%	0.4	0.5	0.5	0.7
Water Conveying System	10 - 30%	2.3	3.6	3.3	4.2
Turbine Generator and Controls	20 - 30%	2.2	4.3	3.5	9.5
Power House & Tail Race	5 - 10%	0.5	0.6	0.6	3.6
Substation	2 - 4%	0.3	0.4	0.4	1.1
Access Roads	0 - 5%	0.0	0.5	0.1	0.2
Powerlines	5 - 15%	0.4 (5 km)	0.7 (10 km)	1.1 (15 km)	4.2 (60 km)
BC Hydro Interconnection	3 - 8%	0.7	0.7	0.8	1.0
Contingency	5 - 15%	1.0	1.7	1.5	3.7
Development & Owner's Costs	2 - 5%	0.4	0.5	0.5	0.9
Permitting and Licensing	5 - 10%	1.0	1.1	1.2	1.3
Engineering	5 - 10%	0.8	1.3	1.2	2.8
Interest During Construction	5 - 10%	0.8	1.3	1.2	2.7
Total Capital Cost		**10.8**	**17.2**	**15.9**	**35.8**
Specific Capital Cost		$2,400/kW	$2,860/kW	$1,990/kW	$1,330/kW

9.3 Taxes

- Land lease rates are generally a small expense of up to $2,000 per year.
- Annual property taxes vary from site to site but are usually 0.5% to 1.5% of the total capital cost.
- Annual water license fees are presently approximately $3,450 per MW of installed capacity plus $1,036 per GWh of energy produced.

9.4 Operation and Maintenance

- Most small hydro projects require one or two full time operators who monitor the power plant operation remotely and inspect the site periodically. Typical annual operator salaries are $50,000 to $80,000 per year.
- Site inspections vary in frequency from once per day during flood season, to once or twice per week.
- Operation for very small, micro hydro projects (under 1 or 2 MW) is often by the owner.
- One, 1-week shutdown is required per year for turbine generator maintenance.
- Turbine generator maintenance is often performed by an outside contractor. Typically two technicians are required for the full 1-week period.

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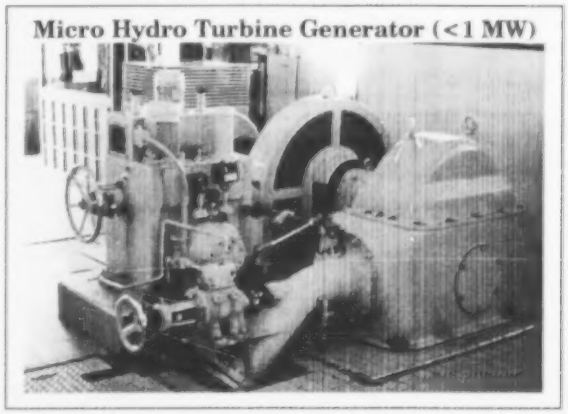

- Annual maintenance costs for the power plant are typically 0.5% to 1% of the total capital cost per year.
- Additional maintenance is required to maintain the powerlines. This cost is typically 3 to 5% of the capital cost of the powerlines per year.
- Civil / site maintenance such as silt removal can often be performed while the turbine is in operation. Frequency and cost of this type of maintenance varies greatly by site.
- Annual insurance costs are on the order of 0.25 to 1% of the total capital cost.
- General and Administrative costs vary greatly by individual project and company but are in the range of 0 to 20% of the total O & M costs.

9.5 Economics

- Excluding debt service payments the total operating expenses including taxes and water license fees are typically on the order of 3 to 5% of the total capital cost per year.
- Debt service payments depend upon the term, interest rate, and debt to equity ratio but are typically on the order of 7 to 10% of the total capital cost per year excluding any return on investment.
- Inflation rates have a small impact on small hydro projects as operating costs and taxes are a much smaller factor than debt servicing which remains fixed. BC Hydro presently escalates the power sales prices by half the consumer price index rate per year.
- The higher a debt to equity ratio allowed by the lender, the better the return on investment is for the owner at a given power price. Debt to equity ratios of 80/20% are desirable (and are used in the following examples) however, lenders often require 75/25% or even 70/30% depending on the owner's credit rating and perceived security of the project.

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Example Project Economics

Project Summary	4.5 MW High Head	6.0 MW Low Head	8.0 MW High Head	27.0 MW Low Head
Capacity Factor	65%	60%	60%	50%
Head	510 m	30 m	460 m	45 m
Design Flow	1.1 m3/s	26.5 m3/s	2.1 m3/s	75.0 m3/s
Total Energy Sales	25.6 GWh/yr	31.5 GWh/yr	42.0 GWh/yr	118.3 GWh/yr
Powerline Cost	$ 400,000	$ 700,000	$ 1,100,000	$ 4,200,000
Total Capital Cost	$ 10,821,600	$ 17,166,600	$ 15,907,860	$ 35,847,900
Annual Taxes & License Fees				
Land Lease	$1,000	$1,000	$1,000	$2,000
Property Taxes	$108,000	$172,000	$159,000	$358,000
Water License	$42,000	$53,000	$71,000	$216,000
Contingency	$23,000	$34,000	$35,000	$86,000
Total Annual Taxes	**$174,000**	**$260,000**	**$266,000**	**$662,000**
Annual O & M Expenses				
Powerline Maint.	$20,000	$35,000	$55,000	$126,000
T/G Maint.	$65,000	$103,000	$95,000	$215,000
Operating Labour	$70,000	$70,000	$70,000	$140,000
Insurance Premiums	$43,000	$69,000	$64,000	$143,000
General & Admin	$20,000	$28,000	$28,000	$62,000
Contingency	$33,000	$46,000	$47,000	$103,000
Total Annual O&M Costs	**$251,000**	**$351,000**	**$359,000**	**$789,000**
Annual Debt Payments	$811,000	$1,287,000	$1,192,000	$2,687,000
Total Annual Expeditures	$1,236,000	$1,898,000	$1,817,000	$4,138,000
Break Even Power Sales Price	$0.048/kWh	$0.060/kWh	$0.043/kWh	$0.035/kWh
Price for 20% ROE (Before tax)	**$0.065/kWh**	**$0.081/kWh**	**$0.058/kWh**	**$0.047/kWh**

Projects above $0.06/kWh may still be economic at non-integrated sites.

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9.6 Life Cycle

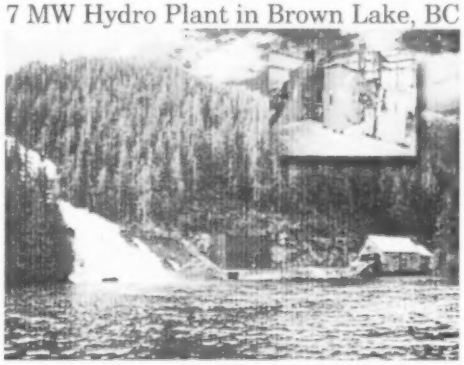
- The life cycle of small hydro projects is on the order of 100 years.
- Most small hydro projects installed around the world are still in operation, including some installed as early as the 1880s.
- Debt financing is usually over a 20 to 30 year term.
- After the initial debt is retired, small hydro projects typically continue to generate high cash flows for the owners for many years.
- Little capital expenditure is required after the initial installation. Some future investment to improve the efficiency and control are often justified.

10.0 PRESENT STATUS AND FUTURE OUTLOOK

10.1 Present Status

- BC presently has approximately 25 small hydro projects in operation, which represents a small percentage of the total economically viable sites.
- Some existing small hydro projects are located in remote, non-integrated, communities such as Bella Coola, Dease Lake and the Queen Charlotte Islands to replace diesel power generation.
- Other projects such as the 7 MW Brown Lake plant in Northwestern, BC and the 14 MW Soo River project near Whistler are integrated into BC Hydro's main transmission system. The 5.3 MW Doran-Taylor located near Port Alberni produces power on Vancouver Island.

7 MW Hydro Plant in Brown Lake, BC



- The 6 MW Hystad Creek project, located near Valemount, was connected to the BC Hydro grid in June 2002. This project has a relatively low capacity factor (~38%) as it is a "run of the river" project located in the interior of the province.
- The 2 MW Raging River project, located near Port Alice, was connected to the BC Hydro grid in May 2002. This project has a high capacity factor (~74%) as it is located on the coast at a site with an existing dam (more than 100 years old) and has significant storage.

10.2 Present Growth Rates

- In 2001/02 BC Hydro signed long term (20 year) power purchase agreements for 20 small hydro projects as part of their 2000/01 call for Green Power Generation. These projects are presently in various stages of development.
- Numerous developers are actively seeking power purchase agreements from BC Hydro. During BC Hydro's 2002/03 call for Customer Based Generation, there were 9 applications for small hydro projects. Of these, 8 were short-listed by BC Hydro for further negotiations. Power purchase agreements are anticipated by the fall of 2003.

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- In 2002/03 BC Hydro issued another call for Green Power Generation and received qualification statement submissions from 53 potential small hydro projects. On March 31st, 2003, BC Hydro announced that 24 of the small hydro projects had been pre-qualified and will be allowed to submit bids for power sales to BC Hydro. BC Hydro will then accept the projects with the lowest offered prices until their target of 800 GWh/yr is reached. Since 3,300 GWh/yr of generation has been pre-qualified, only a small percentage of these projects (~25% based on energy) will be successful in achieving power purchase agreements. The remaining ~20 projects, plus the 29 that were not pre-qualified, must wait at least one year until BC Hydro's next call for tender. Note that the Brilliant Expansion project being developed by Columbia Power (a crown corporation) would fulfill half of BC Hydro's energy target. If this project is selected, it would reduce the number of power purchase agreements to private IPPs by half.
- Development of small hydro generation in BC is mainly limited by the number and price of power purchase agreements issued by BC Hydro.
- Based on recent contracts, approximately 5 to 10 projects may be developed per year.

10.3 Resource Capability

- In addition to sites actively being pursued or developed, bench top studies of maps and hydrology have identified more than 100 potential small hydro sites which may be able to produce power economically at today's electricity prices (~$0.05 to $0.06/kWh). The total combined sales from these projects would be in the range of $220 million per year.
- As power prices rise, the potential resource increases significantly, as smaller and more remote projects become economic.

Approximate Number of Potentially Economic Sites By Power Price (REF 1)

Economic Power Price	Sites	Energy (GWh/yr)	Approximate Annual Sales	Capacity (MW)
$0.05/kWh and lower	**138**	**4396**	**$220 million**	**944**
$0.05/kWh to $0.07/kWh	169	2698	$160 million	639
$0.07/kWh and above	449	3618	$250 million	871

Note that the power prices in the above table (from ref 1) were calculated using optimistic assumptions.

10.4 Typical Project Development Schedule

- Small hydro projects typically require a minimum of approximately 4 years from initial development to power production.
  - Approximately 1 year is required for initial mapping, stream flow measurement, feasibility studies, etc.
  - Approximately 1 to 4 years are required for permitting, licensing, negotiation of the power purchase agreement, and arranging financing.
  - Approximately 1 to 2 years are required for engineering, procurement, construction and installation.

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11.0 GOVERNMENT REVENUE

- Small hydro projects will generate a significant amount of additional provincial government revenue through water license fees, property taxes and land leases.
  - Water license fees: ~$40,000 to $200,000 per year, per site.
  - Property taxes: ~$100,000 to $400,000 per year, per site.
  - Land lease payments: up to approximately $2,000 per year, per site.
- Additional government revenue is also generated by corporate and personal income taxes.
- In three of the last ten years, BC Hydro has become a net importer of power from outside of BC. Increased power generation from small hydro projects will help to ensure that BC Hydro remains a net exporter of power and is not subjected to the significant price spikes which have been common over the past few years.

12.0 INPUT / OUTPUT TABLES

The economic inputs and outputs from small hydro projects will vary significantly from site to site. The following table gives factors for a few sites of several sizes in order to show the relative magnitude and trends of the various input/output factors.

Small Hydro Input Factors

	Units	4.5 MW Project	6.0 MW Project	8.0 MW Project	27.0 MW Project
Investment					
Total Capital Cost	$ millions	10.8	17.2	15.9	35.8
Water Requirements					
Head	meters	510.0	30.0	460.0	45.0
Flow	m3/sec	1.1	26.5	2.1	75.0
Land Area Requirements					
Intake & Structures	hectares	2	2	2	2
New Roads	hectares	0.0	11.1	2.2	4.4
New Powerlines	hectares	8.6	15.0	23.6	90.0

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Small Hydro Output Factors

	Units	4.5 MW Project	6.0 MW Project	8.0 MW Project	27.0 MW Project
Revenue					
Annual Revenue @$0.06/kWh	$millions/yr	1.5	1.9	2.5	7.1
Property Tax / Water Rental	$millions/yr	0.2	0.3	0.3	0.7
Sales / Land (including P.L.)	$ / hectare	$145,000	$67,000	$91,000	$74,000
Sales / Land (excluding P.L.)	$ / hectare	$769,000	$144,000	$598,000	$1,101,000
Construction / Development Employment					
Development	person-years	14	16	17	22
Design / Engineering	person-years	8	13	12	28
Construction	person-years	34	57	52	123
Permanent Employment					
Operations	permanent jobs	1	1	1	2
Maintenance	permanent jobs	0.4	0.7	0.8	1.7

Notes:

1. Land area for powerlines assumes they are installed in a new right of way. If the powerlines are installed along an existing road, land requirements would be reduced.
2. Development employment assumes average salaries of $100,000 per job including benefits. Construction employment dollars estimated at 50% of construction costs.
3. Employment multipliers for indirect and induced jobs have not been included and would be in addition to the employment opportunities identified above. Data from BC Stats indicates that indirect & induced employment multipliers are on the order of 1.2 to 1.4 for construction industries and 1.1 to 1.3 for "high tech" which may be similar to engineering and development.

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NOTE 1. This building block focuses on "run of the river" small hydro projects that do not have significant water storage.

NOTE 2. All dollar figures quoted in Canadian dollars (March 2003).

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